

## Replantation of avulsed primary incisors: a critical review of a controversial treatment

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**Key words:** avulsion; replantation; primary teeth; review

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Accepted 16 January, 2013

**Abstract** – Compared with the abundant literature on the replantation of avulsed permanent teeth, the literature on replantation of avulsed primary teeth is significantly more limited. A search of PubMed, using the terms: primary teeth, primary incisors, avulsion, exarticulation, replantation and reposition, and search in the reference list of the relevant articles, revealed 16 case reports of replantation of 31 primary incisors in 24 children. This article is a critical review of the arguments against replantation that have been presented in textbooks, review articles, and clinical guidelines.

Avulsion of primary teeth has been reported to comprise between 5.8% (1) and 19.4% (2) of all types of traumatic injuries to the primary dentition and 19.2% of luxation injuries only (3). It occurs most often in 2–4-year-old children (4) and affects boys 1.2–1.5 times more than girls (5). The maxillary primary central incisor is involved more than any other tooth (3, 6, 7), followed by maxillary lateral incisors and mandibular central incisors (6). There are reports of avulsion of canines and molars as well, but they are extremely rare (8–10). The main causes of avulsions of primary teeth are falls, fights and child abuse (6, 11, 12). Avulsion of a primary incisor is often associated with luxation injuries to adjacent teeth (13), fracture of the facial bone (11) and laceration of the surrounding gingiva and lips (7, 11, 13–15).

Three options are possible for management of an avulsed primary incisor: (i) no treatment (i.e., avoid replantation) (16), (ii) prosthetic replacement of the missing tooth (10, 17) and (iii) replantation of the avulsed tooth (13).

While publications, including *in vivo* and *in vitro* studies, on the various aspects of replantation of avulsed permanent teeth are abundant, the replantation of primary incisors has received only scant and superficial attention in the dental literature. A search of PubMed, using the terms: primary teeth, primary incisors, avulsion, exarticulation, replantation and reposition, and the reference lists of the articles found, revealed only 16 articles published since 1925 (13–15, 18–30) and one review article (16). While a few textbook chapters have related briefly to avulsion of primary teeth

(31, 32), not a single research investigation has been published regarding the success rates and outcomes of replantation of primary teeth.

The purpose of this article is to provide a critical review of the arguments against replantation that have been presented in textbooks, review articles and clinical guidelines.

### Review of the literature

The sixteen sporadic case reports published since 1925 document the replantation of a total of 31 primary incisors in 24 children. Comparing the reports, it appears that the clinical conditions, the means of handling the teeth before, during and after replantation, and the outcomes to the primary teeth and their permanent successors varied greatly. Moreover, such essential data as children's age at the time of injury, extra-oral time, the medium in which the tooth was kept during the extra-oral time, follow-up duration and outcome to the permanent teeth is often missing. Summarizing these reports: the patients' age at time of injury ranged between 9 months and 6 years (mean, 2-years 11 months); 17 teeth were maxillary central incisors, four maxillary laterals and 10 mandibular incisors. Five teeth were replanted within a few minutes of injury, 10 were replanted after a lapse of 30–60 min, five after 2–5 h and three teeth were 3–4 days out of their socket before being replanted. The roots of 13 incisors (five maxillary and eight mandibular) were dislodged out of the alveolar bone but still attached to

the gingival tissue (13, 15, 20, 24, 25). Twenty-one teeth were splinted and nine were subjected to root canal treatment. No data exists for the postreplantation treatment of three teeth and two teeth neither received treatment nor a follow-up examination after replantation (28, 29). Follow-up periods ranged between 25 days and 5 years and 4 months. The replantation of 13 primary teeth was defined by the authors as successful and six as failures requiring early extraction; for 12 primary teeth, no data on outcomes were provided, or the data were irrelevant due to a very short follow-up period. Following replantation, six of the permanent teeth erupted normally, three had minimal white opacity in the enamel and two failed to erupt: one because of dilaceration of the root and the other because of a radicular cyst. No data were available regarding the 20 remaining permanent teeth.

Incomplete reports, missing data and diversity of treatment modalities make it difficult to draw conclusions from the cases described. Based on current knowledge of supportive treatment for replanted permanent teeth (33), it is not surprising that six of 19 articles that documented replantations of primary incisors and provided the outcome data reported on failures. This may be due to insufficient or lack of supportive treatment following tooth repositioning.

Textbooks and articles that relate to the treatment of avulsed primary teeth have generally rejected the idea of replantation of these teeth (10, 12, 32, 34–42). Some authors have suggested using fixed or removable appliances to fill the gap created from early loss of maxillary primary incisors (10, 17, 36, 43, 44).

In recently issued updates of guidelines for the treatment of avulsed primary teeth, the American Academy of Pediatric Dentistry (AAPD) (45) and the International Association of Dental Traumatology (IADT) (46) recommended avoiding replantation of avulsed primary teeth because of potential damage to the developing permanent tooth germ.

#### **Arguments against replantation mentioned in the literature**

Textbooks, review articles and guidelines on traumatic injuries to primary teeth have traditionally opposed replantation for a number of reasons:

##### **Children have no esthetic demands**

Moss (47) stated that: 'children do not become aware of the loss of a primary incisor prior to age five or six...It doesn't make a great deal of difference to them because their classmates also lose their incisors'. As yet, no report has been published in the English language dental literature on self-esteem or body image of preschool children following premature loss of primary teeth. Nevertheless, there is evidence that parents of young children who lose their primary incisors are interested in replanting the avulsed teeth (48, 49). It is relevant that a number of articles have described techniques aimed to restore the esthetic appearance of the anterior maxillary segment in preschool children who

have suffered from discolored, severely decayed or missing teeth. These include bleaching of dark discolored incisors following trauma (50), reconstruction of severely decayed teeth (51) using post and crown (43, 52–56) and fixed or removable appliances (10, 17, 36, 43, 44). The observation that the body image of 5-year-old girls with a high weight status (weight to height percentile) was lower than that of those with a lower weight status is evidence that preschool children do care about their appearance (57).

##### **Financial costs, time consumption, and lack of children's cooperation**

Hill (41) and Kenny et al. (42) have suggested that treatment costs, as well as the time required for dental visits, are factors to be considered before reaching a decision on replantation of avulsed primary teeth. Wilson (40) and Kupietzky's (10) comments about poor patient cooperation are surprising, because both suggest a prosthetic replacement for the missing primary incisors, a procedure that requires a very high level of child cooperation and the child, according to the author, was 'less than cooperative'. Currently, lack of child cooperation should not be considered a contraindication for dental care, since controlling children's behavior using conscious sedation is an integral part of advanced pediatric dentistry. Although, sedation is not free of risk, it is used routinely by pediatric dentists for conservative dental treatment other than replantation of avulsed primary teeth.

##### **Risk of pulp necrosis and external root resorption**

Andreasen and Andreasen (34, 58) claimed that replantation of primary teeth is not justified due to the risk of pulp necrosis. Obviously, the pulp of an avulsed tooth is expected to become necrotic, due to detachment from its original blood supply: revascularization of the pulp can be expected only in young permanent teeth with an open apex (59). Harrison (36) concluded that replantation of primary teeth can hardly be justified based on the observation of rapid external resorption of the root. The association between pulp necrosis and external inflammatory root resorption has been known for many years (60) and removal of the necrotizing pulp shortly after replantation of avulsed permanent teeth has long been a well-established requirement in treatment guidelines (33, 61). In primary as in permanent teeth, if the pulp is not removed after replantation, external inflammatory root resorption is an obvious complication. It is therefore not surprising that of the 14 primary teeth described in the literature that had no endodontic treatment following replantation, only one survived (16). The process of endodontic treatment in primary teeth has been described in detail, both with the tooth in place (62) and extraorally (27).

##### **Replantation may inflict damage to the permanent successor**

The most commonly proposed argument against replantation of primary incisors is the risk of damage to the

developing permanent successor (10, 16, 34, 35, 37, 40, 45, 47, 63). According to Andreasen & Andreasen (34) damage to the developing permanent successor may result from a coagulum that is forced into the area of the follicle during insertion of the avulsed primary incisor back into its socket. Moreover, they claimed that the frequent development of pulp necrosis subsequent to replantation and associated with inflammation, pose a risk to the permanent tooth bud (34). However, there is no evidence to support this claim. Further, the same authors who warned against defects inflicted to the permanent tooth when the root of the primary tooth is pushed back into the socket, described, in a leading textbook (31), the repositioning of an orally luxated primary incisor: the root of the primary incisor that was dislodged from its socket in a labial direction is pushed back into the socket and toward the bud of the permanent tooth. It is not clear how replantation increases the risk to permanent successors more than does repositioning of labially luxated teeth. A case report on repositioning of two orally displaced teeth with a long-term follow up showed only a minor hypocalcified area in the enamel of the permanent successors (62). Moreover, a histological study in dogs showed that removing the blood clot by rinsing the alveolar socket with physiological saline before replantation reduces the risk of damage to the permanent tooth (64).

The authors of two case reports described severe damage to permanent incisors (impaction because of a radicular cyst) (28) and impaction and dilacerations (29) following replantation of primary predecessors. Attributing the damage to the replantation procedure, they recommended against replantation of avulsed primary teeth. However, except for a 2-day splint in one case (29), the replanted teeth did not receive any supportive treatment and were not followed clinically or radiographically until the patients complained of lack of eruption of the permanent tooth. Moreover, damage to developing permanent teeth has been shown to occur after avulsion of primary teeth, even without replantation (2, 6, 65–68).

#### **Lack of scientific evidence**

Recommendations against replantation of primary teeth (16, 38, 42) have been justified by claims that the evidence is only anecdotal and based essentially on single case reports. Indeed, our knowledge about replantation of primary teeth is based upon sporadic case reports, as are many of the arguments against replantation. Controlled experimental studies in humans and animals have not been performed, nor has a single anecdotal case report demonstrating damage of replantation of a primary incisor to the permanent teeth been published. However, several surveys have reported incidence rates of defects to permanent incisors following avulsion of primary predecessors in the range of 38%–85% (2, 6, 65, 66, 69).

The lack of evidence that replantation of a primary incisor may inflict damage to its permanent successor does not mean that such risk does not exist. Šmelhaus (18), Kokich et al. (70) and Filippi et al. (27) proposed

a simple and elegant solution to the risk of damage to the permanent tooth. They suggested resection of the apex of the root of the primary tooth by one-fourth to one-fifth of its length prior to replantation.

#### **Ankylosis**

Ankylosis has been mentioned in a number of articles as a complication associated with replantation of primary teeth (10, 35, 47, 71–73). According to Levine (71), ankylosis of replanted primary teeth occurs when the root has been stripped of its periodontal membrane, allowing the joining of the cementum and the bone. Fried (35) attributed the development of ankylosis to the splint used to immobilize the replanted tooth. Ankylosis of a replanted primary tooth has been considered to interfere with eruption of the permanent tooth and to cause delayed or ectopic eruption of the permanent successor (47, 71–73). However, a thorough review of reports on replantation of avulsed primary teeth did not reveal any mention of ankylosis (13, 15, 19, 21, 23, 25, 27). Moreover, Sakellariou (14), Mueller (22) and Kawashima (24), who were aware of the literature on risks of replantation, did not find evidence of ankylosis in their evaluations of teeth they had replanted. This in itself does not mean that ankylosis is not a possible outcome of replantation of primary teeth. In fact, extraction and replantation of primary teeth has been performed to intentionally induce ankylosis (70), such as in the application of this procedure in primary canines to obtain abutments for anteriorly directed orthodontic forces aimed to protract the maxilla. The procedure was based on extraction, endodontic treatment and curettage of the root to remove any remaining periodontal fibers, and to perform resection of the root apex and replantation after 45 min extra-oral time. It seems that even if a replanted primary incisor does become ankylosed, it will not become submerged, as the rate of growth markedly decreases from birth until 8 years of age (74).

Ankylosis of teeth following traumatic injuries occurs when osteoclasts originating from the surrounding alveolar bone and subsequently osteoblasts, reach the root surface after crossing the damaged periodontal ligament (PDL) and precementum (75). Injuries to supporting tissues are the most frequent type of trauma in primary teeth (58). Hence, one would expect the occurrence of ankylosis following all types of injury to the supporting tissues. Yet, reports on ankylosis of traumatized primary teeth relate only to intruded primary incisors that failed to re-erupt (76, 77). It is not impossible for primary teeth to become ankylosed following luxation injuries. This has never been investigated and has even been overlooked because infraocclusion has not been reported to present with ankylosis of primary incisors.

#### **Risk of aspiration**

Killian (78) criticized Kawashima & Pineda (24) for not splinting replanted teeth, and thus exposing a child to the danger of aspiration. This criticism is justifiable.

In any case, in which dental trauma affects supporting tissues by causing teeth to become loose, the teeth must be splinted to adjacent unaffected teeth. As ankylosis does not seem to be a problem, long-term splinting time can eliminate the risk of aspiration.

#### Arguments supporting replantation mentioned in case reports

The majority of the articles reporting on replantation of avulsed primary teeth do not provide any justification for the treatment. Other article mention a list of problems attributed to early loss of maxillary primary incisors and claim that replantation of the avulsed teeth may prevent the problems. Among them are impair esthetic (19, 21, 25, 27, 30), space loss (21), delayed eruption of the permanent successor and its malposition following eruption (15, 26, 27), faulty speech development (26, 27, 30) and difficulties in chewing and mastication (27, 30). One cannot argue with parents' demand to restore their child's esthetic appearance by replantation of the avulsed teeth. However, the majority of problems mentioned above are weakly supported by clinical investigations and are largely anecdotal (29), and moreover, there is no proof that replantation prevents these problems. Delayed eruption and malposition of permanent incisors were found also following injuries to the primary teeth that were not associated with early loss of the permanent successor (66).

Replantation of avulsed primary incisors requires periodic recall examinations including multiple radiographs till the exfoliation/extraction of the tooth that pose a health hazard to the patients. Although correct, this argument against replantation of primary teeth may be claimed against any conservative treatment provided to primary teeth that had experienced severe traumatic injury other than avulsion such as intrusion and complicated crown fracture. Yet, there is a consensus in the dental literature that recommends retention of these teeth with a conservative treatment and follow up till natural exfoliation.

#### Discussion

In the absence of scientific evidence on the treatment of avulsed primary teeth, textbooks and review articles present authors' personal views, which generally recommend against replantation. Careful reading of these publications evokes the feeling that they are tendentious. In his discussion of injuries to the primary dentition, Johnson recommended that: 'Avulsed primary teeth should be given to the tooth fairy!' (79). The general attitude of the dental literature toward the treatment of traumatized primary teeth was summarized by Moss and Maccaro (47) in the sentence: 'Heroic methods designed to maintain the primary incisors following trauma should be discouraged'.

Lack of guidelines for replantation of avulsed primary teeth has resulted in decisions based on intuition rather than discretion. There is thus no rational basis for conclusions on the best treatment modality for

avulsed primary teeth. However, the treatment protocol for avulsed permanent teeth (33) can be modified and adapted to fit the specific needs of primary teeth. Modification is needed due to several differences and factors to be considered: (i) patient ages and children's capability to cooperate and follow instructions at a young age, (ii) parents' compliance with postoperative instructions, (iii) the temporary nature of the primary dentition with the inborn tendency of the root of primary teeth to resorb and (iv) the proximity of avulsed primary teeth to the developing permanent successors.

When children lose permanent incisors, they are generally old enough to accept treatment (the 'Tell- Show-Do' behavior management technique is usually sufficient), to follow postoperative instructions, and to clean their teeth and avoid swallowing when rinsing their mouth with an antiseptic solution. In younger age groups, however, pharmacological means may be necessary to achieve children's cooperation during treatment, and adults' compliance is needed as well. Parents should be provided with detailed instructions for oral hygiene and for the application of chlorhexidine gluconate to the gingival margins surrounding the replanted teeth.

Due to the proximity of the developing permanent tooth bud to the socket of the primary incisor, special attention should be paid when manipulating instruments into the socket. To assure that the permanent tooth is at no risk of damage during replantation, the root apex of the primary tooth should be resected, as described by Filippi et al. (27).

It seems that before replantation of primary teeth can be recommended in the complicated case, as delineated below, replantation of primary teeth should be performed under ideal conditions. For suggested technical steps for replantation of primary incisors see Appendix 1.

Replantation should be avoided in the following cases:

- 1 When the crown of the permanent successor is not yet completely developed.
- 2 Children with systemic diseases that may aggravate the treatment or decrease its success rate.
- 3 Children with behavior disorders whose compliance with postoperative instructions is expected to be problematic.
- 4 Multiple avulsions (no adjacent abutment teeth for splinting).
- 5 Avulsion of the coronal fragment of a tooth with root fracture.
- 6 Severe fracture of the alveolar bone.
- 7 Tooth close to natural shedding.
- 8 Root resorption due to previous trauma.
- 9 Severely decayed teeth.
- 10 Teeth that had infected PDL prior to avulsion.

To replant an avulsed primary tooth while the PDL is still vital, the tooth must be repositioned within 15 min (80). This can be achieved only if the avulsed tooth is replanted at the site of injury. Awareness of the public to the recommendation to reposition avulsed permanent teeth as soon as possible may lead to imme-



diate replantation of avulsed primary teeth by parents or by another layperson who may later seek the aid of a dentist. In such cases, if the preliminary conditions contraindicate replantation as mentioned above – remove the replanted tooth. If they do not contraindicate replantation, the replanted teeth should not be removed. Such teeth should receive optimal supportive treatment (i.e., endodontic treatment, splinting, etc.) and follow up to increase the chances of the teeth's survival, and to decrease the risk of damage to the permanent successor.

Conversely, if the tooth is not replanted immediately at the site of injury, the PDL should not be expected to maintain its vitality. The total time interval from injury to the moment the avulsed tooth is ready to be replanted, or even until the tooth is immersed in Hank's Balanced Salt Solution, may be too long. Too many steps are needed during this period of time: it must be realized that the child lost a tooth; the tooth must be looked for and found; the child must get to the dental office and the dentist must be available to provide emergency treatment; medical history should be obtained and clinical examination and radiograph taken; parents need be informed about the possible risks, benefits and alternatives to the procedure; the child's cooperation need be achieved using sedative drugs; and local anesthesia must be obtained at the site of treatment and the socket prepared for replantation. After such a long extra-oral time, the PDL and the pulp can be considered as necrotic.

The widespread recommendation to refrain from replantation of avulsed primary incisors seems to be based mainly on opinions and assumptions rather than on solid evidence. The literature is scanty and limited to a few case reports only. The fear of being accused of causing damage to permanent teeth is only one explanation for the high consensus among dentists and their compliance with current recommendations. Lack of clear and reasonable guidelines, and of long-term studies showing high success rates have also contributed to dentists' decisions to avoid replantation. Not less important is the financial aspect of the treatment. Parents and dentists may be convinced that replanting an avulsed primary incisor is of the best interest of the child. However, as long as insurance companies do not consider the welfare of the patient first and foremost (81) and their program does not cover replantation of primary teeth, parents who are interested in replantation of their child's tooth must cover the costs by their own resources.

It should be noted that replantation of primary teeth is not riskless. Lack of child cooperation requires the use of sedation.

## Conclusion

Presently, replantation of avulsed primary incisors is not 'evidence-based care' and therefore cannot be formally recommended. However, a general attitude of 'look for the evidence' should be adopted, rather than negation based on anecdotal evidence from statements made in published works.

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## 1 Appendix

Suggested technical steps for replantation of primary incisors

### Immediate treatment

#### When tooth has been replanted immediately at site of injury

- 1 Assure the tooth is in its appropriate position by clinical observation and a radiograph.
- 2 Splint the replanted tooth to adjacent unaffected stable teeth. Splint should be as close as possible to the incisal edge to allow effective cleaning of the tooth at the gingival margin. The splint should be removed when risk of spontaneous exfoliation no longer exists. Expected time: 14 days.
- 3 Remove necrotic pulp within 7–10 days, fill the root canal with a resorbable paste and restore the crown and seal the margins of the restoration to avoid leakage.

#### After extended extra-oral time

- 1 Shorten the root by resection of 2–3 mm of the apex.
- 2 Drill the palatal aspect of the crown to get access to the pulp chamber. Remove the necrotic pulp and fill the root canal and pulp chamber with a resorbable paste, and remove any excess of material extending through the apex. Restore the crown.
- 3 Remove any remnants of the necrotic PDL mechanically by scraping the root surface and chemically by soaking the root in sodium hypochlorite.

- 4 Soak the root in a saturated citric acid solution for 3 min, rinse with normal saline, embed in 1% Stannous Fluoride solution for 5 min, rinse with normal saline, embed in 1% doxycycline (or tetracycline) solution for 5 min and rinse with normal saline. The aim of this procedure is to slow the pace of external replacement root resorption.
- 5 Provide local anesthesia.
- 6 Rinse the socket with saline to remove the blood clot. If necessary gently use an instrument to check the socket for fractured alveolar bone.
- 7 Replant the tooth back to its socket.
- 8 Assure the tooth is in its appropriate position by clinical observation and a radiograph.
- 9 Splint, as described above.

### Postoperative instructions

- 1 Soft diet till replanted tooth becomes immobile.
- 2 Consider the use of antibiotics.
- 3 The importance of oral hygiene should be stressed to the parents. Thorough oral hygiene should be kept especially at the gingival margins surrounding the replanted teeth where chlorhexidine gluconate should also be applied.
- 4 The parents should be asked to return for periodic follow-up examinations or earlier if they have any suspicion of deterioration of the condition.

### Follow up

The purpose of the follow-up examination is not only early detection of postoperative complications but also for identification of conditions that have the potential to elicit pathological processes that may endanger the developing permanent teeth or be indicative of failure of replantation. Poor oral hygiene is the most prominent example of such a condition as infection of the PDL is the main cause of failure. The first follow-up examination of the child should be 24 h after replantation to assure the integrity of the splint. Two week later, tooth mobility is checked and splint removal considered; root canal treatment performed (if not done at the first visit); and oral hygiene evaluated and instructions reinforced. The time interval till the next follow-up examination depends on the findings in the last checkup and on the risk potential. If no complications observed or suspected the visits can be at 1, 3, and 6 months and then every 6 months.

Successful replantation of a primary tooth can be defined as retention of the replanted tooth till natural exfoliation at the appropriate dental age and eruption of the permanent successor.